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Development of Time Domain VIV Response Analysis Method Based on Measured VIV Hydrodynamic Force

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Summary: A time domain analysis method of Vortex Induced Vibration (VIV) was developed for risers and towing pipes with curvature. Risers are increasingly installed in deepwater and catenary shape is used utilizing increasing relative flexibility. For example, riser designs such as Steel Catenary Riser (SCR), Compliant Vertical Access Riser (CVAR), Lazy Wave Steel Catenary Riser, etc. are investigated and put to practical use. Other application areas of deepwater pipe structures are CO₂ dilution into ocean concerning global warming. Long towed pipe is used in the moving ship concept. Long pipe structure is also used in deepwater mining. VIV is expected for the inclined pipes. Quantitative analysis of VIV behavior is becoming increasingly important to estimate the fatigue damage of the structures. A time domain VIV simulation method was developed. The analysis method is basically a nonlinear FEM (Finite Element Method) of underwater line structure. The VIV hydrodynamic force is calculated at each time step consulting database of VIV hydrodynamic force. VIV hydrodynamic force on a real scale pipe section subjected to harmonic oscillation was measured at high Reynolds number and arranged into a database. A numerical filter which evaluates amplitude, frequency and phase of local response of a riser from the time history of pipe vibration was developed. Using this filter, response parameters of local vibration is evaluated, and consulting the database and amplitude and phase of VIV force is estimated. The evaluated instantaneous VIV force is applied to the riser. From the procedure the time domain response of pipe is calculated. The validity of the method was verified by comparison with small scale and large scale experimental results carried out in the towing tank. The accuracy of the method is discussed.

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